FORM PTO-1390 (Modified) (REV 11-98) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER	U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR)
PERKINS-15321	09/857880

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/GB99/03857	22 November 1999	12 December 1998

TITLE OF INVENTION
PROCESS AND APPARATUS FOR IRRADIATING FLUIDS

APPLICANT(S) FOR DO/EO/US
PERKINS, John, Patrick

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☐ A copy of the International Search Report (PCT/ISA/210).
8. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 13 to 20 below concern document(s) or information included:

13. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ Certificate of Mailing by Express Mail
20. ☐ Other items or information:

531 Rec'd PCT 12 JUN 2001

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
09/857680	PCT/GB99/03857	PERKINS-15321

21. The following fees are submitted:.

	CALCULATIONS PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :	
☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1,000.00**	
☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but Internation Search Report prepared by the EPO or JPO **$860.00**	
☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$710.00**	
☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$690.00**	
☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**	
ENTER APPROPRIATE BASIC FEE AMOUNT =	**$860.00**
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).	**$0.00**

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	8 - 20 =	0	x $18.00	**$0.00**
Independent claims	1 - 3 =	0	x $80.00	**$0.00**
Multiple Dependent Claims (**check if applicable**).			☐	**$0.00**
TOTAL OF ABOVE CALCULATIONS			=	**$860.00**
Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) (**check if applicable**).			☐	**$0.00**
SUBTOTAL			=	**$860.00**
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)).			+	**$0.00**
TOTAL NATIONAL FEE			=	**$860.00**
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (**check if applicable**).			☒	**$40.00**
TOTAL FEES ENCLOSED			=	**$900.00**
				Amount to be: refunded $
				charged $

☐ A check in the amount of to cover the above fees is enclosed.

☒ Charge above fees to credit card. Credit card payment form enclosed.

☐ Please charge my Deposit Account No. in the amount of to cover the above fees.

A duplicate copy of this sheet is enclosed.

☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. **082670** A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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William H. Holt
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NAME

20766
REGISTRATION NUMBER

JUNE 12, 2001
DATE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of

PERKINS, JOHN PATRICK

New U.S. National Stage Application of International Application No. PCT/GB99/03857

International Filing Date: 22 November 1999

Attention: DO/EO/US

For: PROCESS AND APPARATUS FOR IRRADIATING FLUIDS

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Please amend as follows:

In the Claims:

Amend Claims 1-5 and 7 as follows:

1. (Amended) An apparatus for subjecting a fluid to irradiation by high intensity ultrasound, the apparatus comprising a generally cylindrical vessel, and a multiplicity of ultrasonic transducers attached to a wall of the vessel in an array that extends both circumferentially and longitudinally so as to radiate ultrasonic waves at a frequency above 10 kHz into a fluid in the vessel, characterised by the vessel being large enough that each transducer radiates into fluid at least 0.1 m thick, each transducer being connected to a signal generator arranged so the transducer radiates no more than 3 W/cm^2, the transducers being sufficiently close to each other, and the number of transducers being sufficiently high, that

the power dissipation within the vessel is at least 25 W/liter but no more than 150 W/liter.

2. (Amended) An apparatus as claimed in claim 1 wherein the power radiated by each transducer is in the range 1-2 W/cm^2.

3. (Amended) An apparatus as claimed in claim 1 wherein the number of transducers, the power of the transducers, and the volume of the vessel are such that the power density is between 40 and 80 W/litre.

4. (Amended) An apparatus as claimed in claim 1 wherein the vessel is double walled, with an inner wall and an outer wall with a space between them, the transducers being attached to the outer wall, the fluid to be treated is enclosed within the inner wall, and the space between the two walls is filled by a low attenuation buffer liquid whose cavitation threshold is above that of the liquid to be treated.

5. (Amended) An apparatus as claimed in claim 1 comprising a plurality of ultrasonic signal generators, each signal generator being arranged to energise a separate group of the transducers.

7. (Amended) An apparatus as claimed in claim 5 wherein at least one group of the transducers resonates at a different frequency to other groups of the transducers, and each signal generator is arranged to energise the respective group of the transducers at their resonant frequency.

Enter the following new Claim 8:

8. An apparatus as claimed in claim 6 wherein at least

one group of the transducers resonates at a different frequency to other groups of the transducers, and each signal generator is arranged to energise the respective group of the transducers at their resonant frequency.

REMARKS

By this Preliminary Amendment, all multiple dependencies in the claims have been deleted, and a minor amendment as to form has been made. New Claim 8 has been added.

A marked up copy showing all the changes made to Claims 1-5 and 7 relative to the previous versions of these claims is submitted as ATTACHMENT A.

Favorable action is courteously solicited.

Respectfully submitted,

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June 12, 2001

ATTACHMENT A

1. (Amended) An apparatus for subjecting a fluid to irradiation by high intensity ultrasound, the apparatus comprising a generally cylindrical vessel [(12, 13)], and a multiplicity of ultrasonic transducers [(14)] attached to a wall of the vessel in an array that extends both circumferentially and longitudinally so as to radiate ultrasonic waves at a frequency above 10 kHz into a fluid in the vessel, characterised by the vessel [(12, 13)] being large enough that each transducer [(14)] radiates into fluid at least 0.1 m thick, each transducer [(14)] being connected to a signal generator arranged so the transducer radiates no more than 3 W/cm^2, the transducers [(14)] being sufficiently close to each other, and the number of transducers [(14)] being sufficiently high, that the power dissipation within the vessel [(12, 33)] is at least 25 W/litre but no more than 150 W/litre.

2. (Amended) An apparatus as claimed in claim 1 wherein the power radiated by each transducer [(14)] is in the range 1-2 W/cm^2.

3. (Amended) An apparatus as claimed in <u>claim 1</u> [or claim 2] wherein the number of transducers [(14)], the power of the transducers [(14)], and the volume of the vessel [(12, 32)] are such that the power density is between 40 and 80 W/litre.

4. (Amended) An apparatus as claimed in claim 1 wherein the vessel [(32)] is double walled, <u>with an inner wall and an outer wall with a space between them,</u> the transducers [(14)] being attached to the outer wall (35), the fluid to be treated is enclosed within the inner wall [(32)], and the space [(36)] between the two walls [(32, 35)] is filed by a low attenuation buffer liquid whose cavitation threshold is above that of

the liquid to be treated.

5. (Amended) An apparatus as claimed in [any one of the preceding claims] claim 1 comprising a plurality of ultrasonic signal generators, each signal generator being arranged to energise a separate group of the transducers.

7. (Amended) An apparatus as claimed in claim 5 [or claim 6] wherein at least one group of the transducers resonates at a different frequency to other groups of the transducers, and each signal generator is arranged to energise the respective group of the transducers at their resonant frequency.

Process and Apparatus for Irradiating Fluids

The present invention relates to a process and an apparatus for subjecting fluids to irradiation by high intensity ultrasound.

If a liquid is subjected to a high ultrasonic intensity, that is to say an intensity greater than about 0.3 W/cm^2 at a frequency typically in the range 10 kHz to 100 kHz, then there is a significant deposition of energy into the liquid through attenuation and non-linear effects. This may lead to physical changes (for example streaming, mixing, or emulsification) or to chemical changes, and the present invention is principally concerned with the latter, which may be referred to as sonochemistry. The most significant sonochemical effects are usually associated with cavitation in the liquid, especially transient vaporous cavitation, which typically only occurs at an ultrasonic intensity above a threshold which is typically above 0.3 W/cm^2 and is different for different liquids.

An apparatus for subjecting a liquid to a very high intensity is described in GB 2 243 092 B (UKAEA), in which a transducer is attached to one end of a tapered resonant coupler, the coupler having a nodal flange; this flange is attached to a sleeve projecting from the wall of a pipe containing the liquid, and the space around the sides and end of the coupler within the sleeve is filled with a coupling liquid such as olive oil. The use of such a nodal flange mounting enables a transducer of higher power to be used, but the apparatus is somewhat complex. It has also been suggested, for example in US 4 433 916

(Hall), to attach a plurality of acoustic transducers directly to the wall of a cylindrical vessel containing a fluid, with a specified phase difference between the acoustic signals applied to adjacent transducers. Similarly, US 4 369 100 (Sawyer) describes attaching ultrasonic transducers to the outer wall of an annular duct so that both the inner and outer walls are set in resonance. And US 2 578 505 (Carlin) also describes a pipe with several transducers attached to the surface arranged in one or more circumferential rings.

According to the present invention there is provided an apparatus for subjecting a fluid to irradiation by high intensity ultrasound, the apparatus comprising a generally cylindrical vessel, and a multiplicity of ultrasonic transducers attached to a wall of the vessel in an array that extends both circumferentially and longitudinally so as to radiate ultrasonic waves into a fluid in the vessel, the vessel being large enough that each transducer radiates into fluid at least 0.1 m thick, each transducer being connected to a signal generator arranged so that the transducer radiates no more than 3 W/cm^2, the transducers being sufficiently close to each other, and the number of transducers being sufficiently high, that the power dissipation within the vessel is at least 25 W/litre but no more than 150 W/litre.

The values of power given here are those of the electrical power delivered to the transducer or the transducers, as this is relatively easy to determine. There will inevitably be losses in converting electrical to acoustic power, and in transmitting the acoustic power

from the transducer into the fluid within the vessel, but these are difficult to assess accurately. The transducer

typically is at least 90% efficient in converting electrical to acoustic power.

The power radiated by each transducer may for example be in the range 1-2 W/cm^2. This is a similar power intensity to that used in ultrasonic cleaning baths, and is above the threshold required to achieve cavitation. The resonant ultrasonic coupler with a nodal flange (as described in GB 2 243 092 B) can achieve significantly higher power intensities, for example radiating more than 10 W/cm^2, but the lower intensity ultrasound generated by the present invention can propagate much further through a liquid, and the stresses in the transducers are much less.

The thickness of fluid into which each transducer radiates, that is the width or diameter of the vessel, is preferably no more than 1.2 m, and in a preferred embodiment the vessel is cylindrical of diameter in the range 0.2 to 0.6 m, such as 0.3 m.

Preferably the number of transducers, the power of the transducers, and the volume of the vessel are such that the power density is between 40 and 80 W/litre, more preferably between 60 and 70 W/litre. Although this does not produce such high power densities as can be achieved with an irradiator as described in GB 2 243 092 (UKAEA), it enables a larger volume to be irradiated and with greater uniformity, at sufficient intensity to cause cavitation; this is partly because very high cavitation levels near the vessel wall can have the effect of shielding parts of the fluid further from the wall.

In a preferred embodiment the vessel is double walled, the transducers being attached to the outer wall, the fluid to be treated being enclosed within the inner wall, and the space between the two walls being filled by a low attenuation buffer liquid whose cavitation threshold is above that of the liquid to be treated.

The width of the gap between the two walls is desirably equal to a quarter wavelength in the coupling liquid (which for a frequency of 20 kHz would be about 18 mm), or an odd-numbered multiple of that distance, to optimise the matching of impedance.

In one embodiment some of the transducers are energized at one frequency and other transducers at a different frequency, for example at 20 kHz and at 40 kHz. This can be very effective at causing cavitation and energy deposition within a fluid.

The invention will now be further and more particularly described, by way of example only, and with reference to the accompanying drawings in which:

Figure 1 shows a longitudinal sectional view through an irradiator apparatus;

Figure 2 shows a longitudinal sectional view through an alternative irradiator apparatus; and

Figure 3 shows a sectional view on the line 3-3 of figure 2.

Referring to figure 1 an irradiator 10 incorporates a stainless-steel duct 12 of internal diameter 0.31 m and of wall thickness 2 mm. To the outside of the wall are attached sixty transducer modules 14 closely packed in a square array. Each transducer module 14 comprises a 50 W piezoelectric transducer 16 which resonates at 20 kHz, attached to a conically flared titanium coupling block 18 by which it is connected to the wall, the wider end of each block being of diameter 63 mm. The transducers modules 14 are arranged in five circumferential rings each of twelve modules 14, the centres of the coupling blocks 18 being on a square pitch of 82 mm. The irradiator 10 also incorporates five signal generators 20 (only one is shown) each of which drives all the transducers 16 in a ring. All the transducers 16 are activated at 20 kHz.

In use of the irradiator 10, a liquid is caused to flow through the duct 12 and each transducer 16 activated. Each transducer 16 radiates 50 watts over a circle of diameter 63 mm, that is an intensity of 1.6 W/cm^2. The energy from all the transducers 16 is dissipated over the cylindrical volume of the duct 12, that is to say over a volume of about 31 litres (that is the volume enclosed by the array of transducer modules 14), so the power density is about 97 W/litre, or about 80 W/litre if the ultrasonic irradiation is also effective 40 mm beyond each end of the array of transducer modules 14.

In one modification, three of the rings of transducers 16 are as described above, while the other two rings resonate at 40 kHz and are driven at that

frequency (the rings being of alternate frequency along the duct 12). The power intensity and power density are as described earlier, but the fluid is consequently exposed simultaneously to two different frequencies generating cavitation. This can produce more effective sonochemical results.

Referring now to figures 2 and 3 there is shown an alternative irradiator 30 which has many features in common with that of figure 1. The irradiator 30 includes a generally cylindrical duct 32 of polytetrafluoro-ethylene (PTFE) of internal diameter 0.31 m and of wall thickness 3 mm, which tapers at each end down to an internal diameter of 0.10 m and a wall thickness of 6 mm provided with a flange 33 for connection to other process ducts (not shown), and has a sealed joint 34 for inspection or cleaning purposes. Around the outside of the duct 32 is a concentric stainless-steel steel tube 35 of wall thickness 1 mm and of external diameter 0.354 m, such that there is a gap 36 of width 18 mm between the duct 32 and the tube 35. Sixty transducer modules 14 are attached to the outer surface of the tube 35 in a rectangular array forming five rings of twelve, the spacing between the centres of the coupling blocks 18 being 82 mm parallel to the longitudinal axis of the tube 35 and 92.7 mm circumferentially. The array of transducers 14 is enclosed by an acoustic shield 38. A coupling liquid such as olive oil 40 is used to fill the gap 36 and is re-circulated from a reservoir 42 by a pump 44. This coupling liquid has a higher threshold for cavitation than water, and has an impedance which is between that of the titanium coupling block 18 and that of the fluid within the duct 32 (typically mainly water,

or an industrial solvent); at a frequency of 20 kHz the wavelength of the sound in this oil is 72 mm, so that the gap 36 is of width equal to a quarter of the wavelength.

In use of the irradiator 30, a liquid is caused to flow through the duct 32 and each transducer 16 is activated by a power supply (not shown) at 20 kHz. The dissipated power intensity and power density are as described in relation to figure 1. The impedance matching provided by the oil in the gap 36 allows more of the applied power to enter the fluid within the duct 32 while reducing erosion at the inner, irradiating, surface of the tube 35.

It will be appreciated that the power intensity in the irradiator 30 may be increased by increasing the numbers of transducer modules 14 in each ring. For example there might be sixteen transducer modules 14 in each ring, if the coupling blocks 18 were arranged on a circumferential spacing of 69.5 mm. This would increase both the power density and the power intensity by 33 percent. It will also be appreciated that the duct 32 can be of any material suited to the liquid being processed, and that it may form part of a pressure vessel. It will also be appreciated that the duct 12 or 32 need not be cylindrical but might for example be of square cross-section.

Furthermore the ultrasonic frequencies or frequencies might be different from those described above, and might be as high as 140 kHz or even 200 kHz, as such high frequencies tend to reduce the risk of cavitation erosion.

Claims

1. An apparatus for subjecting a fluid to irradiation by high intensity ultrasound, the apparatus comprising a generally cylindrical vessel (12, 32), and a multiplicity of ultrasonic transducers (14) attached to a wall of the vessel in an array that extends both circumferentially and longitudinally so as to radiate ultrasonic waves at a frequency above 10 kHz into a fluid in the vessel, characterised by the vessel (12, 32) being large enough that each transducer (14) radiates into fluid at least 0.1 m thick, each transducer (14) being connected to a signal generator arranged so the transducer radiates no more than 3 W/cm^2, the transducers (14) being sufficiently close to each other, and the number of transducers (14) being sufficiently high, that the power dissipation within the vessel (12, 32) is at least 25 W/litre but no more than 150 W/litre.

2. An apparatus as claimed in claim 1 wherein the power radiated by each transducer (14) is in the range 1-2 W/cm^2.

3. An apparatus as claimed in claim 1 or claim 2 wherein the number of transducers (14), the power of the transducers (14), and the volume of the vessel (12, 32) are such that the power density is between 40 and 80 W/litre.

4. An apparatus as claimed in any one of the preceding claims wherein the vessel (32) is double walled, the transducers (14) being attached to the outer wall (35), the fluid to be treated is enclosed within the inner wall

(32), and the space (36) between the two walls (32, 35) is filled by a low attenuation buffer liquid whose cavitation threshold is above that of the liquid to be treated.

5. An apparatus as claimed in any one of the preceding claims comprising a plurality of ultrasonic signal generators, each signal generator being arranged to energise a separate group of the transducers.

6. An apparatus as claimed in claim 5 wherein, in each said group, the transducers are adjacent to each other.

7. An apparatus as claimed in claim 5 or claim 6 wherein at least one group of the transducers resonates at a different frequency to other groups of the transducers, and each signal generator is arranged to energise the respective group of the transducers at their resonant frequency.

WO 00/35579 PCT/GB99/03857

Fig.1.

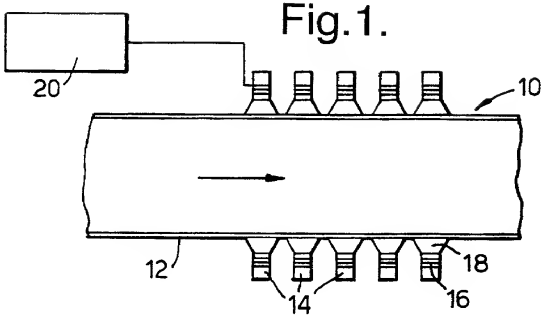


Fig.2.

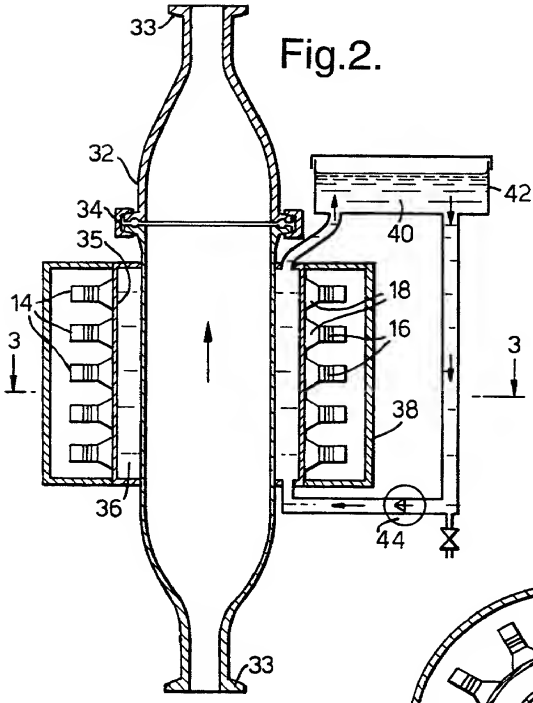
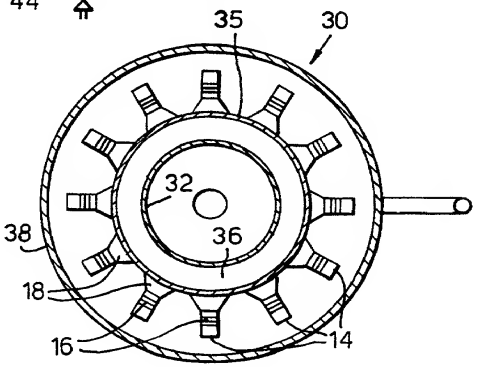


Fig.3.



COMBINED DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION (USA)

(INCLUDING DESIGN PATENT APPLICATIONS)

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled Process and Apparatus for Irradiating Fluids

the specification of which is attached hereto, unless the following box is checked:

[ ] was filed on 22nd November 1999 as United States Application Number or PCT International Application No. PCT/GB99/03857 and was amended on 16th October 2000 (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

(Number)	(Country)	(Day/Month/Year Filed)	Priority Claimed [X] Yes [ ] No
98 27360.0	United Kingdom	12th December 1998	
			Priority Claimed [ ] Yes [ ] No

[ ] Additional applications identified on attached sheet.

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

(Application Serial Number)	(Filing Date)	(Status) (patented, pending, abandoned)
(Application Serial Number)	(Filing Date)	(Status) (patented, pending, abandoned)

[ ] Additional applications identified on attached sheet.

I hereby appoint the following attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Full name of Second Joint Inventor	Inventor's Signature	Date
Residence		**Citizenship**
Post Office Address		
Full name of Third Joint Inventor	Inventor's Signature	Date
Residence		**Citizenship**
Post Office Address		

[ ] See attached sheet for similar information and signatures for additional joint inventors.